

Does structure matter? The impact of switching the agricultural policy regime on farm structures

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Does structure matter? The impact of switching the agricultural policy regime on farm structures

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Abstract

This paper investigates the relationship between structural change in agriculture and a policy regime switch at the regional level. Using the agent-based spatial and dynamic simulation model AgriPoliS, we simulate structural change for two different farm structures in response to a policy change. Results show that structural adjustment differs depending on the initial structure.

JEL Classification codes: C15, Q12, Q18

Keywords: Simulation, agent-based modeling, structural change, policy analysis, agriculture

1 Introduction

Many people associate two things with European agriculture. One is that farming is very diverse across regions in terms of farm size, structure, and specialization. For example, farm structures range from mostly family-operated small-scale farms, such as in France or southern Germany, to large-scale agricultural holdings with many employees and thousands of hectares in Germany's 'Neue Länder', as well as in many of the New Member States of the European Union (EU). The second association is the magnitude of government support programs for farming as implemented in the European Union's Common Agricultural Policy (CAP). In 2003, subsidies accounted for 33% of agricultural gross-production (OECD 2005b). In the United States and Australia, the same figure was 18% and 4%, respectively. This corresponds to 775 € per hectare of utilized agricultural land in the EU (100 € per hectare in the U.S.). Since the early 1990s, several reforms have introduced a major shift in the way the EU provides income support to farmers. Guaranteed prices have been reduced and replaced with compensatory payments. The most recent reform, in 2003, took this development further by providing farmers with decoupled payments based on historical entitlements that replace the per hectare compensatory payments (EU Commission 2003). The new policy regime is referred to as decoupled because payments are independent of production decisions and should not exert an influence on production decisions.¹

This paper is motivated by the 2003 reform of the direct payment system for decoupled direct

¹ In fact, agricultural economists have repeatedly advocated decoupled direct payments (e.g., Swinbank and Tangermann 2000, Baffes 2004, Beard and Swinbank 2001, Dewbre et al. 2001, Lewis et al. 1989, OECD 2001).

payments. Moreover, governments in many EU countries introduced similar decoupled direct payment schemes despite great variations between regions and farm structures. In view of that, this paper investigates the extent to which differing farm structures determine the impact of a policy change and subsequent structural change. Specifically, the study considers how a policy regime switch influences structural change in two distinct regional farm structures in Germany. The first region, Hohenlohe, located in the state of Baden-Württemberg in the western part of Germany, is characterized by family-farming and intensive livestock production. The second region, in the state of Saxony, is an arable farming region in which producer cooperatives, limited liability firms, and partnership farms dominate production.

Studies have investigated the effect of decoupling direct payments on production responses and land allocation (e.g., Moro and Sckokai 1999, Burfisher and Hopkins 2003, Young and Westcott 2000); some authors put a special focus on risk and uncertainty (e.g., Hennessy 1998, Sckokai and Moro 2006). Other studies focus on the impact on land prices, the capitalization of payments and investments (e.g., Goodwin et al. 2003, Lagerkvist 2005, OECD 2005a, Roberts et al. 2003, Turvey et al. 1995, Weersink et al. 1999) as well as on the degree of decoupling (e.g., OECD 2004, Swinbank and Tranter 2005).

However, issues such as the policy impact on farm structures and structural change, as well as distributional impacts, have been neglected. One explanation for this lack may be shortcomings of traditional agricultural policy models. These models are typically of four types: econometric models, single farm and regional models based on mathematical programming, general equilibrium models, and partial equilibrium sector models. Of these, regional and sector models based on mathematical programming are a popular means of analyzing the impact of decoupled payments and other EU policies.² The EU's switch from price support policies to more direct means of granting support have made econometric approaches less suitable (Heckelei and Britz 2005). Many of the new policies such as decoupled direct payments have no historical precedent and they induce a structural break in the system. Regional and sector programming models aggregate farms into representative groups of farms of a specific type (e.g., Heckelei and Britz 2001, Offermann et al. 2005). However, these approaches are mostly comparatively static and they use a sample of representative or average farms.

In this paper we use the agent-based model AgriPoliS (Agricultural Policy Simulator) (Happe et al. 2006, Happe 2004) to simulate the impact of a policy regime switch on structural change. AgriPoliS is a normative spatial and dynamic model of agricultural structures and explicitly takes account of actions and interactions (e.g. rental activities, investments, and continuation of farming) of a large number of individually acting farm agents. Accordingly, AgriPoliS allows for endogenous structural change and is thus particularly suited to analyzing structural, allocative, and distributive effects of policy changes on a region's agricultural structure. In contrast to many other policy models in agriculture such as single farm and regional mathematical programming models, the agent-based approach is suitable for explicitly modeling the land market to reflect the local interactions of farms, which is crucial in regard to distributional as well as the dynamic effects of agricultural policies. Compared to agent-based models in economics, AgriPoliS is very detailed in its model parameters. The model is initialized with an empirical-based farming structure that provides a close approximation to observed regional characteristics such as the share of arable land use. Individual farm agents are specified based on individual farm data on farm organization and production.

Agent-based models have increasingly been used to model agricultural and resource problems, but with a focus on the interactions between socio-economic and environmental

² For an overview of the state of the art of modeling agricultural policies, please see Arfini (2005).

systems and land use problems (Balmann 1997, Barreteau and Bousquet 2000, Berger 2001, Bousquet et al. 1998, Evans and Kelley 2004, Deffuant et al. 2002, Parker and Meretsky 2004). AgriPoliS has been previously used to analyze the impact of different policy schemes. Happe et al. (2005a) analyze the impact of decoupling schemes on structural change in the Hohenlohe region in southwest Germany, and Happe et al. (2005b) investigate the impact of policies intended to raise the efficiency of agricultural structures. In this paper we apply the same approach, but focus on comparing structural change in two fundamentally different regions.

The remainder of the paper is structured as follows. In Section 2, we show key characteristics of farm structures in two regions in Germany. In Section 3, we briefly present the AgriPoliS model, followed by the empirical adaptation to the two case study regions in Section 4. In Section 5, we define policy scenarios and show simulation results. Section 6 concludes with a summary and discussion.

2 Characteristics of farm structures in Germany

To provide a better notion of the differences in farm structures in Germany, we will present some key characteristics of farm structures in the Eastern and Western parts of Germany (Table 1). We have provided some key indicators for Saxony and Baden-Württemberg, the two German states in which the case study regions are located and that clearly exemplify the structural differences.

- TABLE 1 HERE -

In 2003, the average size of a holding in Saxony was 200 hectares, while in the Western parts of Germany this was only 37.1 hectares (BMVEL 2005). In addition, whereas in West Germany, 5% of all farms have more than 100 hectares of land managing 27% of West Germany's utilized agricultural area, in East Germany, 32% of all farms have more than 100 hectares and manage 92% of the area (Statistisches Bundesamt 2004).

3 The simulation model

3.1 The concept

The agent-based model AgriPoliS is a spatial and dynamic agent-based model that simulates endogenous structural change in agriculture.³ The core idea of AgriPoliS is the understanding and modeling of the agricultural system as an agent-based system in which farms are interpreted as individual agents. Therefore, heterogeneous agents are situated in an environment in which they interact, co-operate, and exchange information with other agents who have possibly conflicting aims. What can be observed at a higher level of scale (region, sector) is the result of actions and interactions at the individual farm level. In this way, it is possible to develop a stylized picture of a system such as the agricultural sector in a specific region in a one-to-one manner as a computer model, which then can be used to simulate changes in the composition of the systems we are modeling. AgriPoliS maps the key components of regional agricultural structures: heterogeneous farm enterprises and

³ Here we only provide a brief overview of the model. A detailed documentation is provided in Happe et al. (2006). AgriPoliS has been written in C++. The reader interested in the program code may directly contact the authors.

households, space, markets for products and production factors. These are embedded in the general technical and political environment.

3.2 Farm agents

Farm agents are key entities in AgriPoliS.⁴ The main element of a farm agent is its behavioral model that determines the decision making process and is therefore responsible for selecting a suitable action out of the available action space, according to the current state of the farm and the state of the farms' environment. A farm agent's decision-making is based on the assumption that farm agents maximize household income. This is a reasonable assumption regarding the behavior of many farming enterprises and farm households in Western Europe.⁵ To derive the farms' actions, a mathematical programming approach is used as a means of combining various farm production activities and investment choices given the farm's resource constraints (cf. Hazell and Norton 1986, Schreinemachers and Berger 2006). Even though we assume a normative behavioral foundation, the farms agents' decision-making can be characterized as myopic or boundedly rational. This assumption holds for two reasons. First, expectations about future prices rely on an adaptive expectation formulation process, even though we assume that farm agents anticipate the impact of major policy changes one period in advance. Second, a farm agent does not act strategically. Whereas this assumption is normally unproblematic on markets where farms are price-takers (which holds generally for agricultural product markets), this is not necessarily true for local factor markets such as the land market, which plays an important role in agricultural structural change. Therefore, land is treated separately, as described later on.

Farm agents can carry out a range of production activities. In order to produce, farm agents utilize different production factors (land, buildings, machinery, liquid capital, labor) of different types and capacities. Regarding the latter, we implement economies of size. AgriPoliS also aims to mimic the effect of technological progress. More specifically, we assume that with every new investment, production costs of the product produced with this investment decrease by a certain percentage. New investments affect production capacities for the operating lifetime of the investment; the salvage value of fixed assets is zero. Hence, investment costs are sunk costs.

In addition to the standard production activities, there are a number of auxiliary activities. Farms can engage in rental activities for land, production quotas, and manure disposal rights. Labor can be hired on a fixed or per-hour basis; conversely, farm family labor can be offered for off-farm employment. To finance farm activities and to balance short-term liquidity short-ages, farm agents can take on long-term and/or short-term credit. Liquid assets not used on the farm can be invested in a bank.

As a result of its actions, the farm agent's internal state changes from one period to the next. A farm agent's internal state is organized as a balance sheet that keeps track of factor endowments, the operator's age, and price expectations, along with a number of financial indicators. These indicators determine whether a farm agent exits or remains in the sector. In

⁴ A farm agent corresponds to the entity of a farm including the farm manager as the decision-making unit and, in the case of family-farms, farm-family members (farm household).

⁵ Using a normative behavioral foundation enables us to derive farm agents' behavior from well-known concepts such as mathematical programming. We are aware that by doing so, we neglect properties such as adaptive behavior of agents over time. However, given the model's detail, it is impractical to include such concepts directly into the model. Instead we follow the approach of isolating specific aspects of farms' decision-making from AgriPoliS and define alternative behavioral models later to support the decision-making of agents in AgriPoliS (cf. Kellermann and Balmann 2006, Balmann and Happe 2001). An example is given in the section about the land market.

AgriPoliS, the exit decision is determined by the level of equity capital and opportunity costs of farm-owned production factors. Accordingly, a farm agent leaves the sector if equity capital is zero or if the opportunity costs of farm-owned production factors are not covered. Handing over the farm to the next generation also affects the opportunity costs of labor because we assume that a successor takes over the farm operation only if the expected income generated on the farm would be at least as high as the comparable industry salary.

3.3 Agent interaction via factor and product markets

In AgriPoliS, farm agents interact indirectly via markets for the production factors land, labor and capital, and on product markets. Markets for products, capital and labor are coordinated via a simple price function with an exogenously given price elasticity and a price trend for each product.

The land market is central to AgriPoliS. The land market as implemented in AgriPoliS gave close consideration to the conditions of German agriculture. These are most notably given by the great importance of land rental as compared to land purchase as a means of farm growth and the direct dependence of livestock production on land to dispose of manure and to produce feedstuff. Accordingly, agents in AgriPoliS extend their hectare base exclusively by renting additional land.⁶

At the beginning of each production period, each agent faces a situation where there are a number of free plots in the region. Various land owners offer these plots to farm agents using a common platform. To mimic this situation, the land market in AgriPoliS is modeled as a sequential first-price auction in which a market agent allocates free plots of farmland to farm agents wishing to rent these plots. In addition, the sequential auction shows itself to be a simple and efficient way of allocating plots.

In brief, the land allocation process works as follows. First, each farm agent produces a bid for a particular plot of land. A reasonable strategy in a sequential auction is using the marginal valuation for a good, in this case land, to derive the bid. Taking the non-convex production function into account, we compute the shadow prices for one additional plot of land and for a fixed number of additional plots. The bid equals the maximum of these two values, less transportation costs between the farmstead and the plot⁷. Second, the auctioneer collects all bids, compares them, and allocates the free plot to the highest bidder. The auction process alternates between arable land and grassland to consider complementarities between different land qualities. If all land has been allocated or bids are zero, the auction terminates.

3.4 Space

AgriPoliS models spatial characteristics in a stylistic way. Spatial relationships are given by transport costs that depend on the distance between farmsteads and plots. Space is represented by a kind of cellular automaton consisting of a grid of equally sized cells/plots. Each cell

⁶ There is, however, a difference between East and West Germany that is due to historical reasons. In the west, the proportion of rented land to owned land has been steadily increasing over the past decades. The opposite is true for the so-called 'Neue Länder', where a large share of land rented out to farmers after German Unification is put up for sale after rental contracts have terminated.

⁷ One critique of this kind of combination between mathematical programming and behavioral rules is that there is often no sound economic or empirical foundation. To overcome this problem, we isolated the land market and used an adaptive learning mechanism based on genetic algorithms to create a benchmark strategy that enables us to compare alternative behavioral rules such as the one we chose above (cf. Kellermann and Balmann 2006). One basic finding is that a reasonable bidding strategy should at least anticipate the size effects of the own production function that we could achieve with the chosen bidding rule.

represents a plot of land of a certain size. Cells can either be farm land (i.e., arable land or grassland) or non-agricultural land (e.g. forests or roads). Farm land is either owned by farm agents or non-farm land-owners. In the latter case, land is rented out to be used by farm agents.

3.5 Technological, economic and political framework conditions

We assume that farm agents operate using assets of different vintages and technological standards. Production technology is assumed to undergo a steady technological progress that is created in the up-stream sector but not on the farms themselves. Farm agents can benefit from technological progress by adopting new technologies, reducing production costs. When adopting new technologies of a type, labor requirements per unit produced decrease with the size of the investment. The political environment is given by the predominant agricultural policy setting. Agricultural (and environmental) policies affect the farm in various ways, for example, prices, stocking density, and direct payments.

3.6 Model initialization and course of events

Before the simulation start, the initial endowments with production factors (family labor, machinery, buildings, production facilities, land, production quota, liquid assets, and borrowed capital) are specified. During the following periods these variables are changed as a result of production, rent, and investment activities carried out by the farm agents. Figure 1 provides an overview of the model dynamics and the course of events during one simulation period.

- FIGURE 1 HERE -

4 Empirical application

We adjust AgriPoliS to the two regions by creating an input data set that represents a virtual farm structure and provides a close approximation to the observed real farm structure in the reference year 2001.⁸ The Saxony region comprises about 479,000 hectares; Hohenlohe about 73,500 hectares. Hohenlohe's farm structure is characterized by small-scale, family-operated farms. On the Hohenlohe plains, many farms specialize in pig and poultry production, while in the valleys there are mostly dairy farms. Because of the excellent soil quality, many farms in Saxony specialize in crop production with livestock production playing only a minor role. Large-scale farms dominate agricultural production in Saxony.

The input data set contains information on the structure and information on 12 to 30 individual farms that one could typically find in the study region. These typical farms represent the structural characteristics of the region. We calibrated the input data set to reflect the production capacities and key economic figures of the chosen typical farms. In order to reflect the regional heterogeneity of the farms, we derived typical farms from farm accountancy data of the European Farm Accountancy Data Network (FADN) as well as general data on prices, technical coefficients, and costs. Although accountancy data provided a very good data source to describe the specialization and economic situation of individual typical farms, data on the kinds and vintage of fixed farm assets are lacking. Based on expert information from regional agricultural authorities, we therefore assume that farm agents in

⁸ For details on the adjustment methodology, refer to Sahrbacher et al. (2005) and Happe et al. (2006).

AgriPoliS operate with buildings, machinery and facilities that are considered to be typical for the region.

For Hohenlohe, we identified a set of 24 typical farms; for Saxony, 30 typical farms were specified. For both regions, the chosen farms correspond to the variety of farm types in the region. To create the initial farm structure of AgriPoliS, we assign weights to each typical farm. The weights are derived in a calibration procedure that minimizes the quadratic deviation between characteristics of the virtual farm structure and a series of observed characteristics of the real region such as the total number of farms, production capacities, or the total utilized agricultural area. For the purpose of AgriPoliS, the weights represent the number of times a typical farm must be located in the region such that the agricultural structure of the region is best represented. Accordingly, we initialize AgriPoliS with 2,857 farms for Hohenlohe and 1,835 farms in Saxony. Thus, the average farm size at the outset of AgriPoliS is 26 hectares for Hohenlohe and 261 hectares for Saxony.⁹ Figure 2 compares the distribution of farm types in reality with the distribution initialized in AgriPoliS.

- FIGURE 2 HERE -

5 Policy experiments

5.1 Policy scenarios

We carried out simulation experiments with three different policies, one baseline policy and two alternative decoupling policies (Table 2). The baseline, Agenda 2000, represents the business as usual scenario. The scenario assumes that the policy prevalent in the year 2001 remains valid throughout the simulation. Under Agenda 2000, there are different area payments per hectare, depending on what is planted. The total subsidy increases with the area produced of a specific type of crop. Moreover, certain livestock (suckler cows, beef cattle) receive headage payments. Because of these properties, payments under Agenda 2000 generate an incentive to produce either specific livestock or to increase the acreage of specific crops.

- TABLE 2 HERE -

The alternative policies represent two distinct ways of decoupling support. They are inspired by the decoupling options of the most recent reform of the CAP, yet they do not exactly reproduce the new policy.¹⁰ The first alternative scenario implements a so-called single area payment scheme (SAP), which is close to the regional model as adopted by Germany. Under the SAP scheme, farmers can claim a fixed area payment for each plot they manage. We assume a uniform payment for arable land and grassland. The payment is derived from the

⁹ Previous analyses showed that it proves to be technically and computationally very demanding to analyze data from 2,800 farms simulated over 25 periods. We therefore simulated a fraction of 20 percent of the Hohenlohe region and a fraction of 33 percent of Saxony while keeping the relative composition of the whole sample. This means that 572 farms are initialized and simulated in Hohenlohe and 612 farms in Saxony. Robustness of the results has been tested through repeated simulations with varying seeds speeds (see Happe 2004).

¹⁰ In fact, the recent reform is more complex since it allows member states to keep some partially coupled payments or to introduce a dynamic component to the introduction of payments (see EU Commission 2003)

total quantity of payments in the region averaged over a period of three years prior to the reform divided by the total number of hectares. The second policy introduces a fully decoupled idealized single farm payment (iSFP). Under this scheme, the owner of the farm receives a payment independent of any farming activity. The amount is based on the historical average payment the farm has received during the three periods prior to the policy change. There is, however, an important difference between this scenario and the single farm payment introduced as part of the actual reform of the CAP. In our scenario, it is unnecessary to continue farming, and owning land is not necessary to receive payments. In reality, payments are only receivable if the corresponding amount of land is also used and farmers stay in business. Both decoupling policies are conditional on keeping farmland in good agricultural condition.

We simulate each policy scenario for 25 time periods. During the first four simulation periods, the baseline policy Agenda 2000 sets the political framework condition before a policy change to one of the decoupled policies sets in. In the simulations, we assume that all farm agents face the same output prices. Unit production costs, however, vary between farms depending on their managerial ability and technical change due to farm investment activity and farm size. Prices for intensive livestock and crops follow a downward trend; labor costs follow an upward trend.

AgriPoliS generates a large output dataset containing information on the farm agents' economic performance, production, and land use at the regional level and the individual farm level. With regard to analyzing structural change, we focus on the analysis of four indicators: farm size, allocative efficiency, rental rates, and profits. We observe the development of farm sizes in the two regions. In Germany, farm growth most often takes place via farm size growth to exploit economies of size. Regarding efficiency, for both regions we observe the development of the average economic land rent, which is a measure of the residual utilization of land after all other production factors (labor, capital) have been paid for. Furthermore, in the introduction we investigate the policy impact on land rental rates. Profits generated through farming activity are the final indicator observed in this analysis. The reader may note that due to space restrictions, some indicators that support the following arguments are not reported here, but they are available upon request.

5.2 Results

The following figures show the evolution of the indicators farm size, rental rates, and profits and should provide an impression about the speed of structural change under the defined policy conditions. Increasing average farm sizes indicates that structural change takes place in all policy scenarios. This reflects some of AgriPoliS's assumptions about economies of size and the effect of technological change.

In both regions, the policy induces a change in the average farm size (Figure 3) and a change in the distribution of farm size classes (Figure 4). In Hohenlohe, a gradual increase in average farm size can be detected for scenarios Agenda 2000 and SAP. Most obviously, the introduction of a decoupled single farm payment (iSFP) represents a structural break. In Hohenlohe, only one half of the farms with fewer than 30 hectares continue after the policy switch (Figure 4). The fact that the single farm payment is granted independently of the farming activity provides an explanation for this. Accordingly, for smaller farms it appears to be more profitable to take the payment and exit farming. A policy switch to the SAP scheme has only a minor effect on the distribution of farm size classes, yet this small effect is due to a redistribution of payments occurring at the introduction of the SAP. Depending on their specialization before the reform, some farms receive fewer payments under the SAP-scheme, which induces a few farms to leave the sector.

- FIGURE 3 HERE –

- FIGURE 4 HERE -

The overall picture is somewhat similar in Saxony, although there are some significant differences. First of all, a gradual increase in farm size can be observed in both Saxony and Hohenlohe for the Agenda 2000 and SAP scenarios, yet the Saxony rate is lower than in Hohenlohe. Second, size classes with farms above 50 hectares hardly change in response to a policy switch. Before policy change, farms below 50 hectares accounted for 33% of all farms, but they farmed only 4% of the total agricultural land. Hence, the sharp decrease in the number of farms in small farm size classes does not offer much growth potential for the remaining farms.

Regarding the capitalization of support in farmland values, Figure 5 shows the differing policy impacts on rental rates. On the one hand, under fully decoupled single farm payments, lower shadow prices for land transfer into lower rental rates. In Hohenlohe, where the rental rates level is generally higher, the fall in rental rates takes place immediately after the policy change. It is remarkable that under the SAP scheme, rental rates for arable land in Hohenlohe increase. Thereby, the mentioned redistribution effect induces more farms to leave under the SAP scheme than under Agenda 2000. On average, the farms leaving are those with relatively lower shadow prices for land. Accordingly, remaining farms with higher shadow prices compete for free arable land and push rental rates upwards. The decoupled single area payment, on the other hand, also transfers into higher rental rates for grassland. The reason is that before policy change, only certain products using grassland, such as suckler cows or beef cattle, received payments. Under the new SAP scheme it is the grassland itself that receives the payment. The impact is particularly strong in Saxony, where rental rates for grassland are three times higher than before the policy switch. This means that around one-third of the area payment of 329 € per hectare is transferred into higher rental rates for grassland.

- FIGURE 5 HERE -

The specific policy impact on rental rates is also reflected in the development of farm profits. Figure 6 shows the evolution of mean profits of identical farms surviving, regardless of the policy scheme, as well as the mean profit of all farms in each period in the baseline scenario.¹¹ It appears that the farms with the best starting position to survive in all scenarios are farms with significantly higher profits than the average at any point in time. Moreover, under the iSFP scheme, profits of surviving farms increase relative to the baseline, but decrease in case of single area payments. This effect is particularly pronounced in Saxony, and it can be explained by the increase in rental rates for grassland. It is important to consider that in Saxony, the proportion of rented land of all farm land is some 90 % at the outset of the simulation. Hence, higher rental rates transfer into lower average profits. In the SAP scheme, farms survive even if they experience an income loss on average due to the policy change. The effect is less evident in Hohenlohe, where around one-third of the land is rented at the outset of the simulation.

¹¹ We considered only surviving farms to avoid the sample effect generated by the exit of farms.

- FIGURE 6 HERE -

Structural change in both regions is accompanied by a change in the economic land rent per hectare of utilized agricultural area (Figure 7). Efficiency growth, however, differs greatly between Hohenlohe and Saxony. Efficiency increases with time in Hohenlohe, irrespective of policy. This is much less pronounced in Saxony; in the case of a single farm payment, land rents even decrease in later simulation periods because of less intensive production and an increasing amount of grassland that is no longer rented by farms. The various origins of labor and the divergent labor productivity explain most of the different efficiency changes between Saxony and Hohenlohe. Due to investments in larger, labor-saving technology, the costs of farm family labor per unit in Hohenlohe decreased in each period by 20 € per hectare, on average.¹² In addition, efficiency increases as a result of policy-independent structural change because particularly small family farms exit and make way for the expansion of other farms. In Saxony, the efficiency increase is less pronounced. Due to the significantly lower share of farm-family labor, adjustment regarding labor takes place by laying off hired labor first. Moreover, cereal production is less labor-intensive than intensive livestock production, which is the dominant form of production in Hohenlohe.

- FIGURE 7 HERE -

As for the impact of decoupling, a single farm payment significantly improves factor allocation as measured by the economic land rent per hectare of land in the region (Figure 7). This is despite only a small effect on profits.

6 Discussion and conclusions

If payments are no longer attached to production, but to land use only through a single area payment (SAP), the agricultural structure is hardly affected compared to the reference. Increasing rental rates for grassland and a redistribution of payments between farms tend to offset profit gains and efficiency increases. Fully decoupled direct payments (iSFP), granted independently of agricultural production, are shown to have landslide effects in small-scale farm structures. Shadow prices for production factors such as land fall dramatically due to policy. Thus, farm agents spend less on leasing land and look for alternative uses of the complementary factors labor and capital. This accelerates structural change.

Considering that farm agents maximize household income, both unprofitable farms and farms with growth potential benefit from a fully decoupled single farm payment. Unprofitable farms benefit because farm agents are rewarded for leaving the sector, despite significantly lower opportunity costs of land. On aggregate, this takes away some strain on the land market, particularly in regions dominated by small farms, as more land is available for lease. The remaining farms have the opportunity to lease land at lower prices and to realize size effects more easily. As these farms' share of leased land is already higher at the outset of the simulation, farms remaining in the sector earn additional income from lower rental rates. In a region dominated by large-scale farms, economies of size are already exploited at the outset such that structural change has only a small effect on efficiency, with the exception being that

¹² We have carried out alternative simulation runs in which we turned off the impact of technological change and managerial ability. The results gave us the pure impact of labor-saving technological change. Here also, the efficiency increase was 17 € per hectare.

farms with better managerial ability replace those with lower managerial ability. Farmers with a high share of rented land benefit from fully decoupled single farm payments due to lower rental rates. Land owners would suffer because lower rental rates are reflected in lower land values. This redistribution of rent from land owners to land operators has, however, consequences for the use of land as a security, particularly for capital-intensive livestock production in regions such as Hohenlohe. Thus, lower land values limit the growth potential of smaller farms through new investments.

The results obtained with AgriPoliS are subject to a number of assumptions that influence the behavior and interactions of farm agents and, hence, the model results. In particular, it should be stressed that we assume labor-saving technical change in addition to the assumptions on technological change and managerial ability. In this paper, we analyzed the consequences of structural adjustment from the farms' point of view and, in only a very basic way, from the societal point of view. However, the process of structural change is multi-dimensional and includes the whole supply and value chain, including food production, processing and distribution industries, and changing societal needs (Balmann et al. 2006, Boehlje 1999, Swinnen 2005). Based on this, one could envision refocusing the analysis of structural change beginning with supply and value chains rather than firms and markets. Food quality and environmental aspects that form another important part of current agricultural policy-making have also been left out. Moreover, farms face equal opportunities with regard to seeking off-farm labor. Nevertheless, the majority of the findings are plausible from a theoretical and empirical point of view. Modeling agents' behavior and interactions represents a starting point for further developments and research. In the process of understanding the behavior of economic agents, behavioral norms other than income maximization and optimization could be explored. As many applications in the field of sociology and communication sciences have shown, it is furthermore possible to introduce explicitly different, not necessarily economic, behavioral patterns into agent-based models.

6 References

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Table 1: Factors generating structural differences between land markets in East and West Germany

East Germany (Saxony)	Key indicators	West Germany (Baden-Württemberg)	Key indicators
Large-scale co-operatives and partnerships with some family farms	Land use by legal form ¹⁾ <ul style="list-style-type: none"> • 61% limited liabilities / produced cooperatives • 12% partnership farms • 21% full-time private farms • 6% part-time private farms 	Mostly family-farms	Land use by legal form ²⁾ <ul style="list-style-type: none"> • 60% full-time private farms • 27% part-time private farms • 13% other
Decisions based on full-cost calculation due to high share of hired labor	Annual labor input: ³⁾ <ul style="list-style-type: none"> • 30% family labor • 49% fix hired labor • 21% seasonal labor 	Decisions based on variable cost calculation, costs of farm family labor often considered as sunk cost	Annual labor input: ³⁾ <ul style="list-style-type: none"> • 68% family labor • 7% fix hired labor • 24% seasonal labor
High share of rented land	Rented land in 2003: 85.2% ⁴⁾	Lower share of rented land	Rented land in 2003: 58.2% ⁵⁾
Lower equity capital endowment due to high share of arable farming	2,377 €/ha equity in 2005 ⁶⁾	Traditional value of land ownership as collateral	9,654 €/ha in 2005 ⁶⁾
Most farms specialize in arable farming	Farm specialization: ¹⁾ <ul style="list-style-type: none"> • 56.9% field crop farms • 32.2% dairy farms • 1.2% livestock farms • 2.3% mixed farms • 7.3% other 	In some regions capital intensive livestock production	Farm specialization: ²⁾ <ul style="list-style-type: none"> • 17% field crop farms • 36% grazing livestock farms • 2% pig/poultry farms • 20% mixed farms • 26% other
Very limited possibilities to use land outside farming due to low population and industry density		Chances of land use outside farming higher due to high population and industry density	
Constant or decreasing returns to scale		Increasing returns to scale	
Historically large farms		Historically, farmland was divided between all heirs	

Source: ¹⁾ LfL Sachsen (2002), ²⁾ Statistisches Landesamt Baden-Württemberg (2005a), ³⁾ Statistisches Landesamt Baden-Württemberg (2005b) ⁴⁾ Statistisches Landesamt des Freistaates Sachsen (2004), ⁵⁾ Statistisches Landesamt Baden-Württemberg (2006), ⁶⁾ BMELV (2006)

Table 2: Policy scenarios

Abbreviation	Scenario name	Scenario description and conditions
REF	Agenda 2000	<ul style="list-style-type: none"> - Full implementation of Agenda 2000 at the end of 2002 - No cross-compliance
SAP	Decoupled single area payment	<ul style="list-style-type: none"> - Payment of 310 € per hectare in Hohenlohe, and 329 € per hectare in Saxony - Conditional on managing land - Cross-compliance: all farmland has to be kept in good agricultural condition (cut at least once a year)
iSFP	Idealized decoupled single farm-payment	<ul style="list-style-type: none"> - Historical payment (3 year average) paid to the farm operator - The payment is independent on the continuation of farming - Cross-compliance: all farmland has to be kept in good agricultural condition (cut at least once a year)

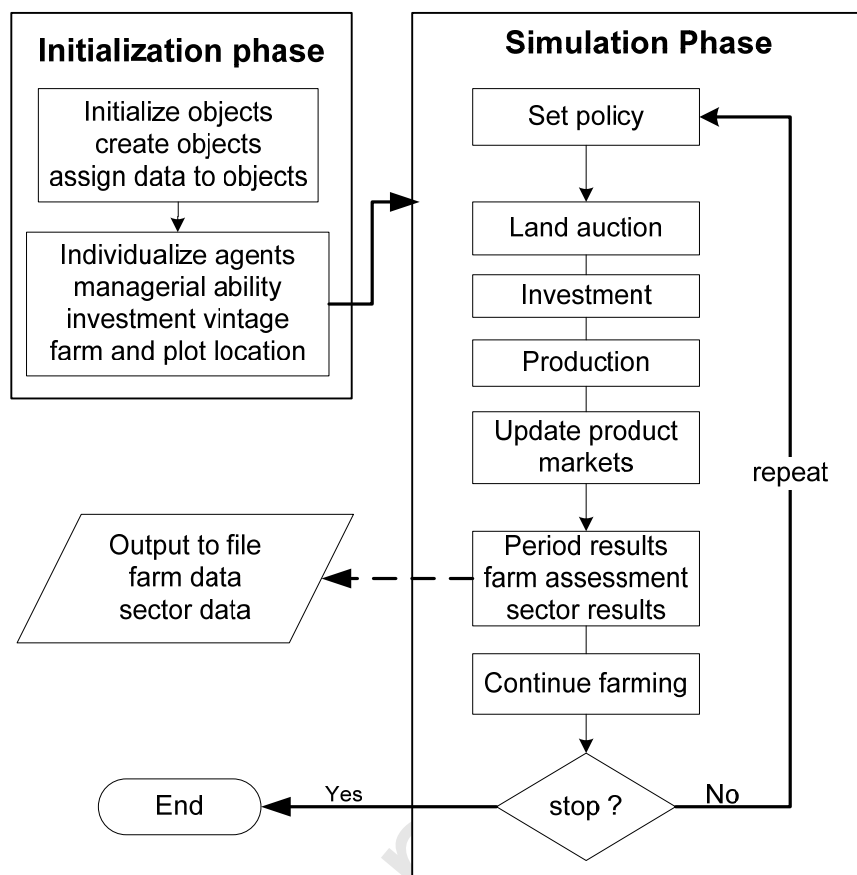


Fig. 1: Model dynamics and course of events during one period

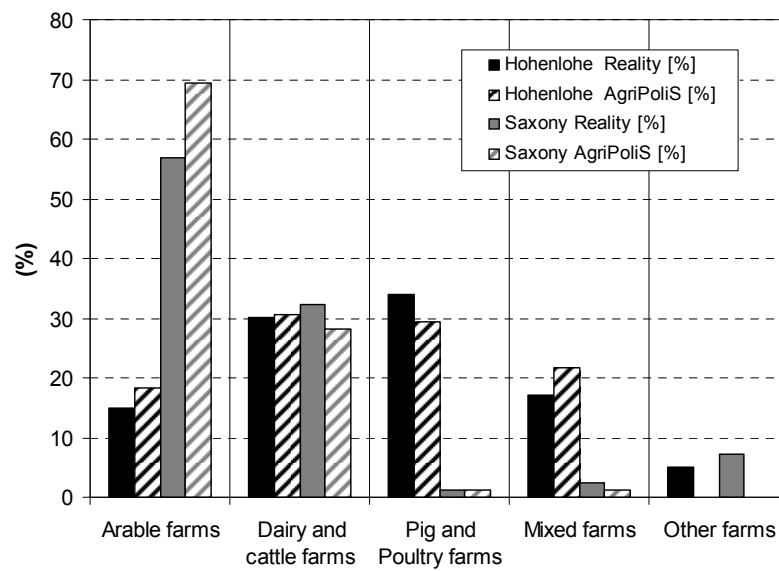


Fig. 2: Distribution of farm types in Hohenlohe and Saxony in reality and as initialized in AgriPoliS (Source: Agricultural Census 1999, LfL Sachsen 2002).

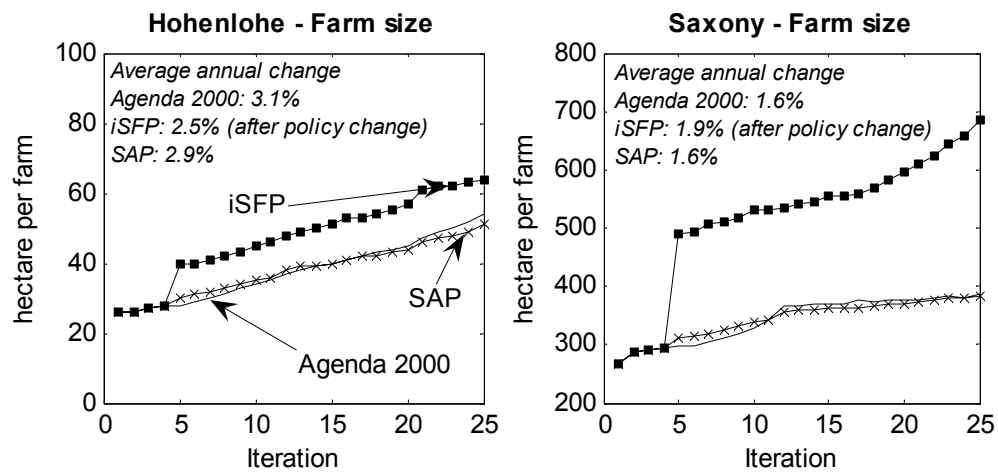


Fig. 3: Development of average farm size over 25 simulation years for the Hohenlohe and Saxony regions.

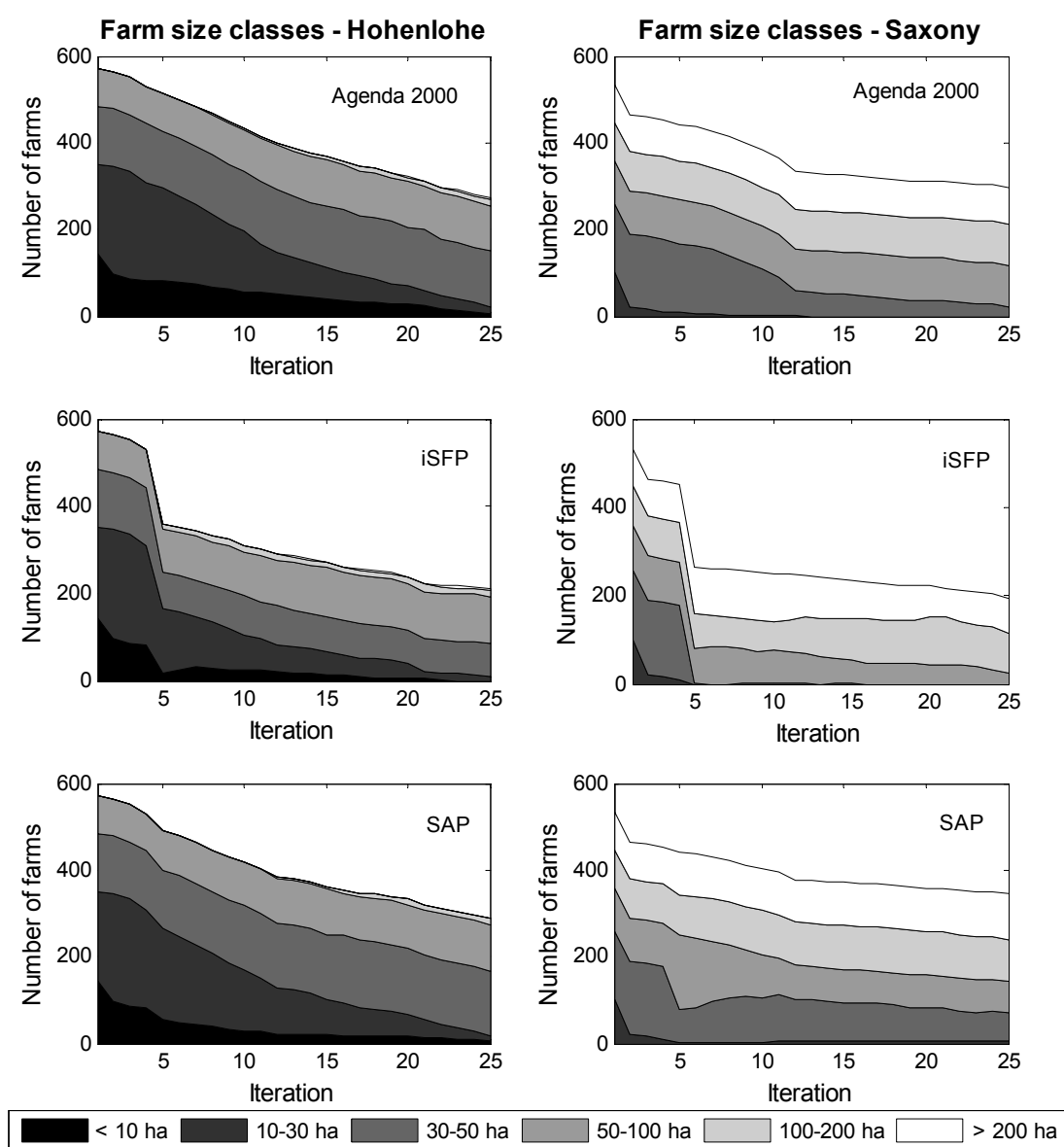


Fig. 4: Development of six farm size classes over 25 iterations for the Hohenlohe and Saxony regions.

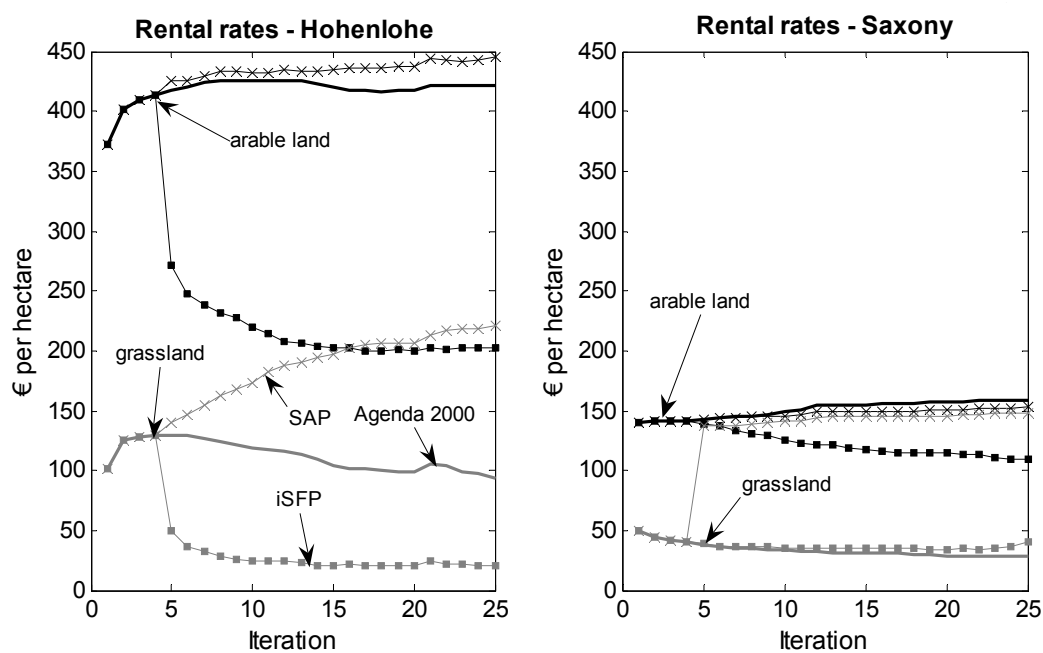


Fig. 5: Development of the average rental rates for arable land and grassland the Hohenlohe and Saxony regions under alternative policy scenarios.

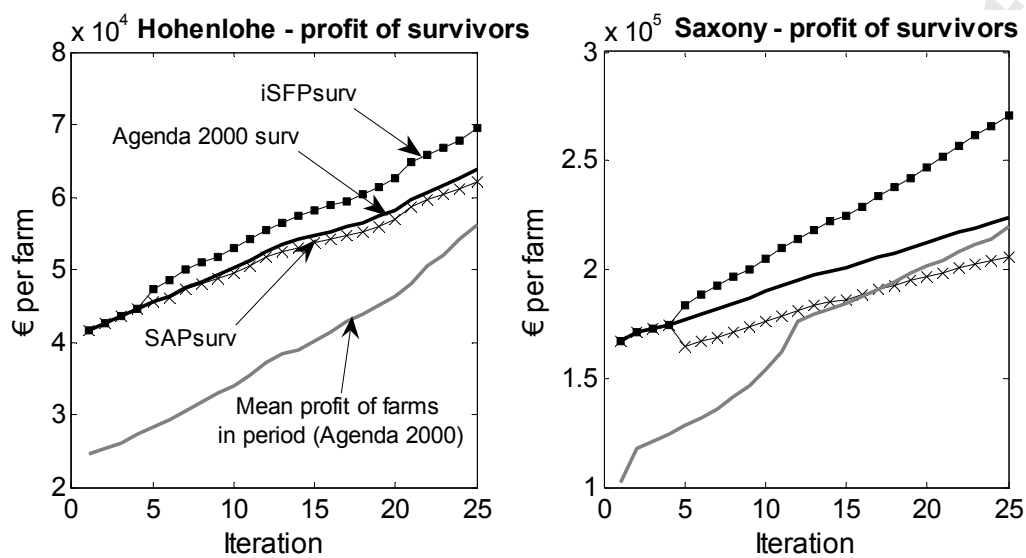


Fig. 6: Development of average profits of farms surviving throughout 25 iterations under all policy schemes.

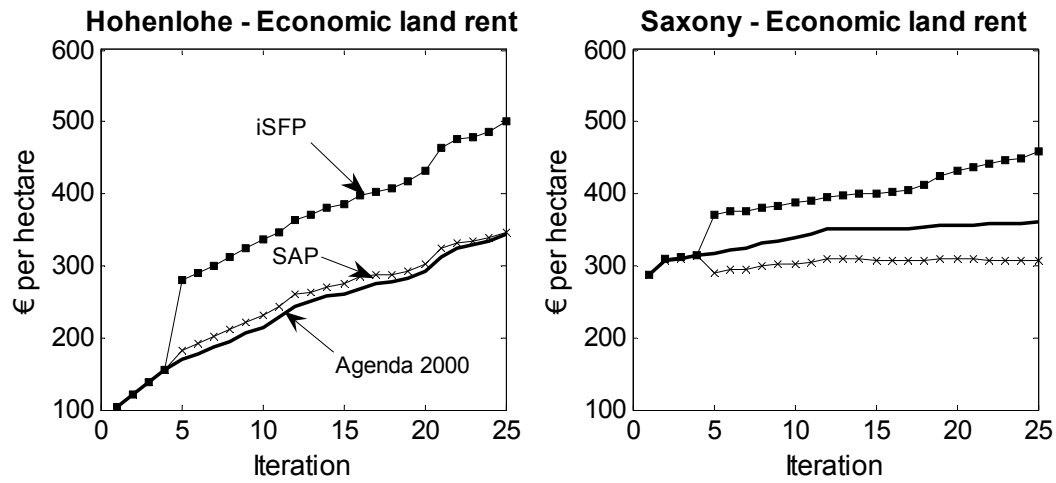


Fig. 7: Development of economic land rent over 25 iterations in regions Hohenlohe and Saxony